Space Weather Technical Forecast

Issued on Friday, 21 January 2022 at 12:43 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight Chance G1/Minor Storm intervals from CME arrivals throughout. Active high energy electron fluence.

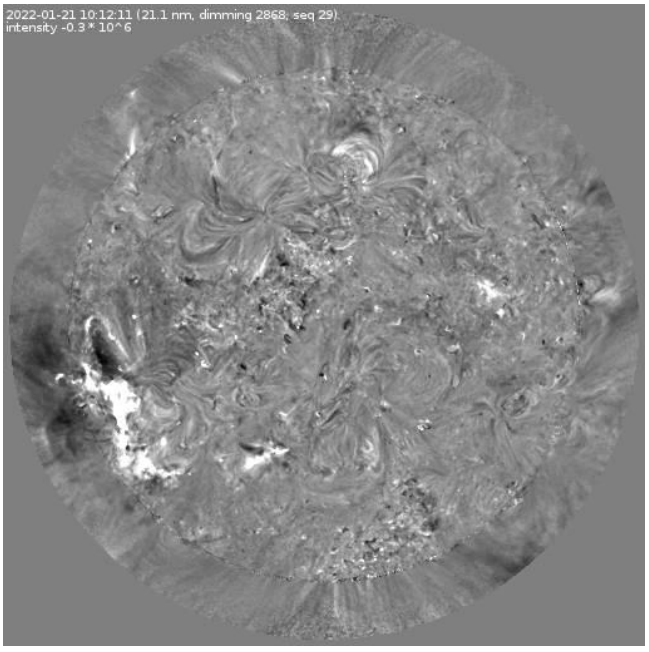
Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity fell to become Very Low in the past 24 hours, with no significant X-ray flares recorded. The number of sunspots on the visible disc also fell, with just two unipolar groups now surviving in the form of 2933, an Hax/Alpha and 2934, an Hhx/Alpha. Two recent large sunspot groups, including that responsible for the recent R2 and S1 (AR2929) now lie narrowly over the western limb beyond analysis (the other being 2930). Finally, 2927 became indistinct near the southwestern limb.

At 21/0900UTC, a large filament disappeared from immediately north of AR2934, with this event visible on H-Alpha imagery for the period (e.g. Udaipur). This was tied to a long-period B-class flare. A Coronal Mass Ejection (CME) was visible in available STEREO COR2 coronagraph imagery, however this is not considered Earth-directed, with no other events of note observed.

Having being emitted prior to this this 24-hour period, there are numerous potential CME glances and near misses in the forecast - all discussed in the Geomagnetic Storms section.

Figure 0: Time-integrated AIA 211 image sequence of dimming tied to the 21/0900UTC filament eruption from the southeastern quadrant. Earth-based effects are considered unlikely. Image processing courtesy of ROB SIDC.



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Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1, was suggestive of an ongoing exit from a negative polarity high speed stream, thought to be that from coronal hole 44, which is now indistinct near the western solar horizon. The phi angle was accordingly negative (towards the sun) throughout the period.

The solar wind speed fell from the upper 500s of km/s to near 400km/s by the period's end. The solar wind density, meanwhile, was unremarkable - within single figures ppcc throughout, with a slight downward trend. The IMF showed a slight decay within background levels: falling slightly from a peak of 5nT, with the north-south component varying between +/-4nT.

The net effect of the above solar wind measures was for provisionally Quiet Kp throughout.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16 showed a declining response from S1 to start the period, having initially being reached in the wake of the M5 flare from AR2929. The proton flux fell from an initial peak of 19pfu at 20/1200UTC to cross below the S1 threshold from 20/1555UTC. The 100MeV proton response also fell, starting the period narrowly below the 1pfu alert threshold and subsequently falling.

High energy electron flux (greater than 2MeV) measured at GOES 16 was at mostly High levels, with a peak value of 2660pfu at 20/1655 UTC. Electron fluence persisted above the 1e8 Active threshold, with a generally steady trend and an observation value of 1.32e8 integrated pfu recorded at 21/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There continues to be a decreasing Slight Chance of further isolated M-class flares given two large sunspots' proximity to the west limb, Ex-2930 and especially Ex-2929 with its recent history. With an otherwise simple Earth-facing disc and no returning regions due, Very Low solar activity is expected into the UTC weekend.

Solar Wind / Geomagnetic Activity: There are three potential CME arrivals through the period. Firstly, there is a chance of a glancing impact either late today (Friday 21 January) or early Saturday from the CME from the M-class flare on 19 January. Secondly, a CME generated by the filament eruption in the southwest quadrant on 20 January may brush Earth with limited impacts on day 4 (Monday 24 January). Thirdly, a further CME which occurred on 19 January has the potential to arrive day 3 (Sunday 23 January), with confidence slightly higher for some limited impacts at Earth for this feature.

In addition to the complicated CME forecast, a pair of coronal holes may become geoeffective from later in the UTC weekend: the doublet of CH45 and CH46.

The resultant forecast is very low confidence in timing and phasing of G1 risk, but higher for this being the maximum attained geomagnetic activity. In the absence of transient effects, Quiet ambient activity should give way to more often Unsettled periods given the more reliable high speeds stream(s) onset(s).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is forecast to slowly decrease back to Background levels in the first half of the forecast period. The chances of further such enhancements should now gradually fall with time from a peak early Slight Chance.

The high energy electron flux (greater than 2MeV) is expected to be continue to at mainly High flux levels throughout the period, but carries low confidence for the likelihood of interruptions from CME arrival and perhaps the more assured reset to lower levels from CH45 and CH46 into

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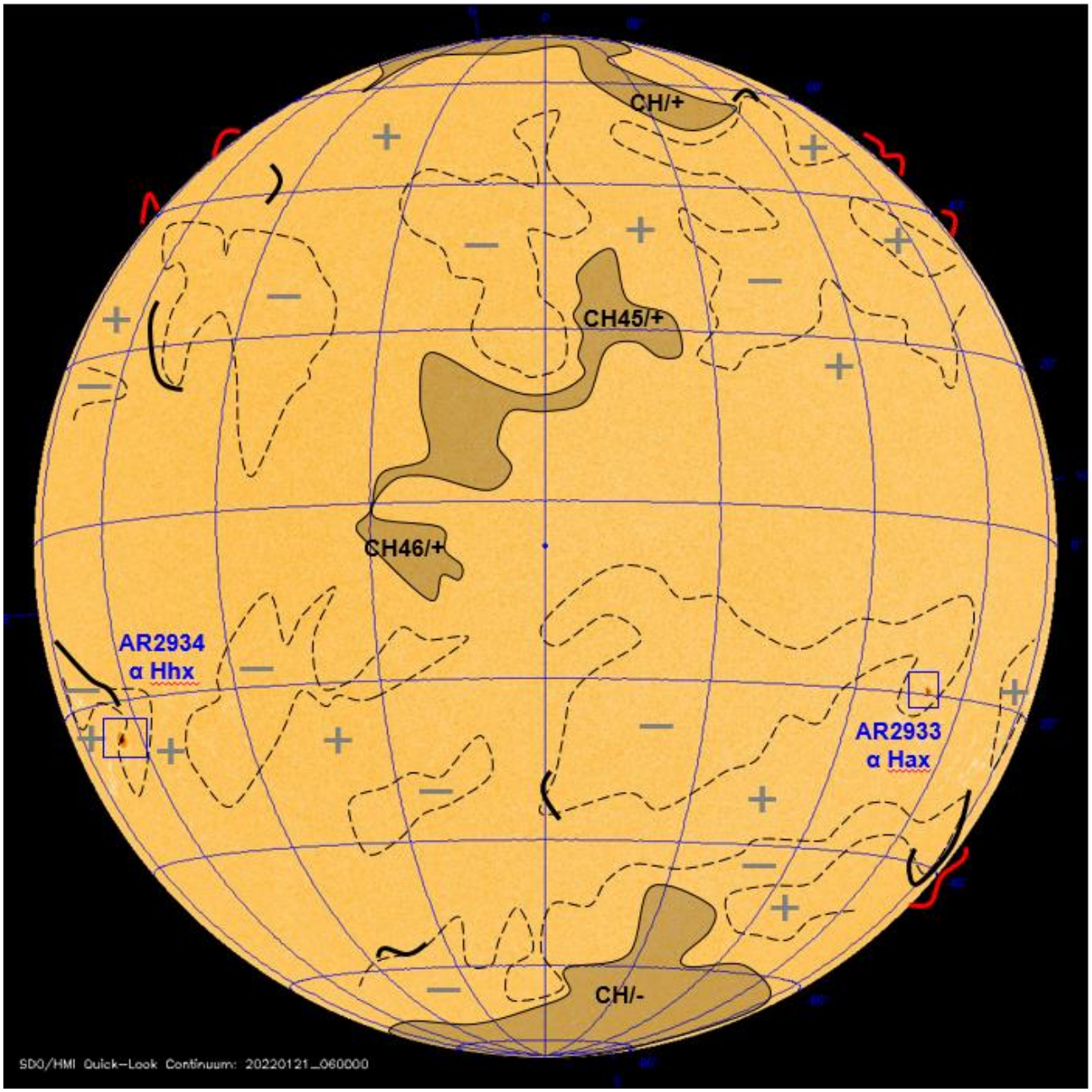
the new UTC working week. The 24-hour fluence is forecast to persist above the Active threshold initially, but with an increasing chance of dropping below this level into the new week.

Figure 1. Solar Analysis Valid 21/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Most succinctly put, there are three potential CME arrivals through the period.

Firstly, there is a chance of a glancing impact either late today (Friday 21 January) or early Saturday from the CME from the M-class flare on 19 January. Secondly, a CME generated by the filament eruption in the southwest quadrant on 20 January may brush Earth with limited impacts on day 4 (Monday 24 January). Thirdly, a further CME which occurred on 19 January has the potential to arrive day 3 (Sunday 23 January), with confidence slightly higher for some limited impacts at Earth for this feature.

In addition to the complicated CME forecast, a pair of coronal holes may become geoeffective from later in the UTC weekend: the doublet of CH45 and CH46.

The resultant forecast is very low confidence in timing and phasing of G1 risk, but higher for this being the maximum attained geomagnetic activity. In the absence of transient effects, Quiet ambient activity should give way to more often Unsettled periods given the more reliable high speeds stream(s) onset(s). The CME observed inside the past 24 hours has yet to be analysed but appears heading eastward in recent STEREO A COR2 imagery to no presumed effect at Earth.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	20	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/2140	Partial	M1.5 from AR2929	N11 W056	950	22/0000UTC	Bulk missing, only weak sideswipe
19/1837	Partial	Filament	S16 W017	288	23/1500UTC	Low confidence in fit with imagery.
20/1642	Partial	Filament	S02 W059	478	24/1200UTC	Likely to pass north of Earth

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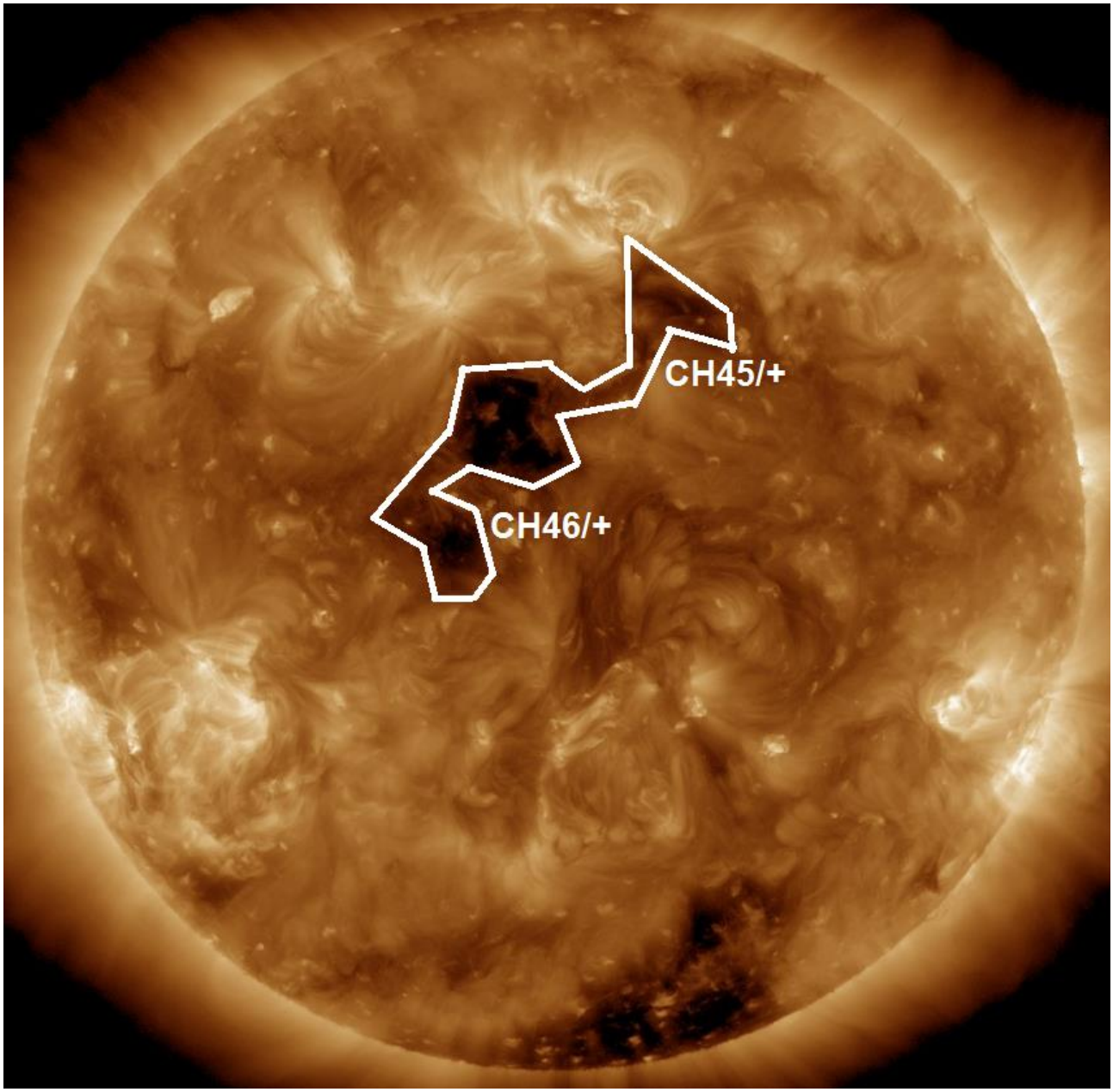
Figure 2: AIA 193 image from 21/1200UTC, showing upcoming coronal holes in the forecast period.



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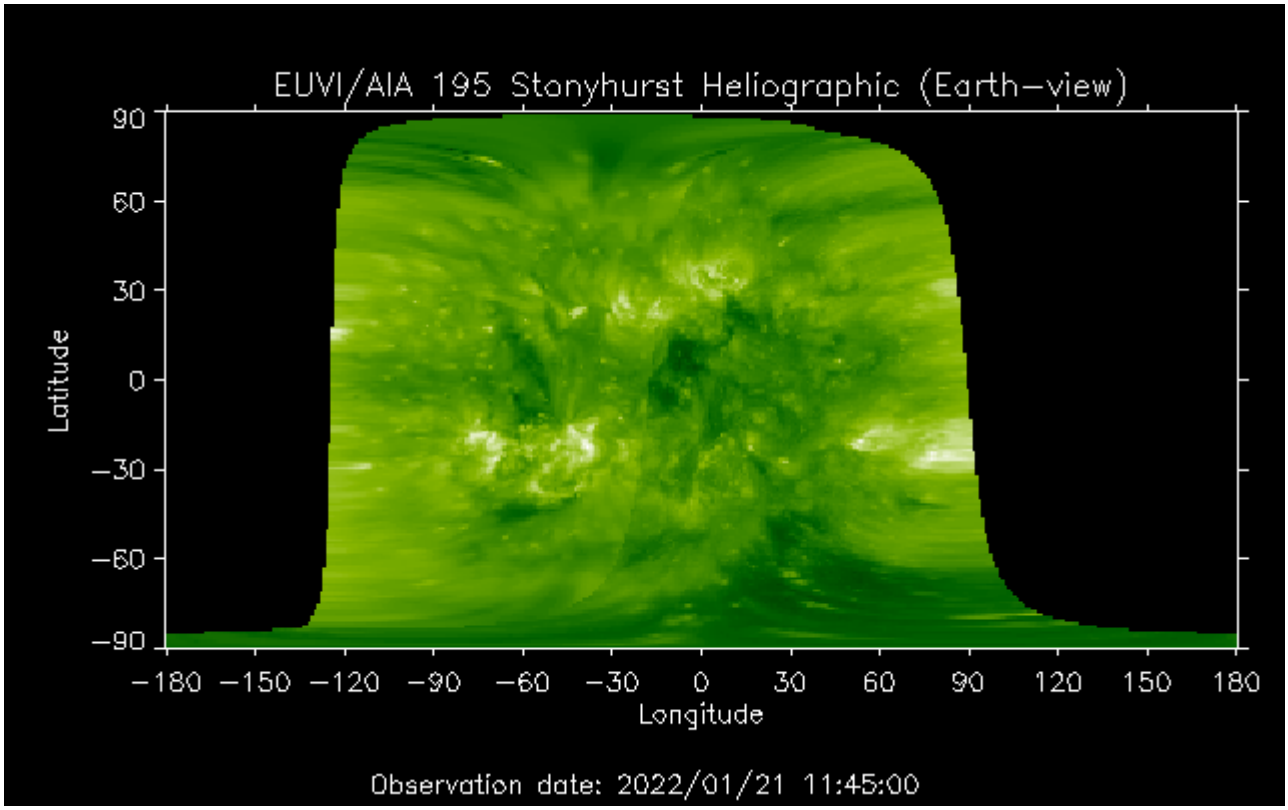
Radio Blackouts - X-Ray Flares:

There are now just two front-sided sunspot regions on the disc, and neither is likely to prove capable of significant flares in their current guise. Given Ex-2929's proximity to the limb, there is still a chance of M-class flares should it throw up ejecta with any force, however this risk soon passes into the UTC weekend. Given the expected lack of returning and newly-developed regions in the region of the sun expected to rotate onto the disc in the forecast period (140E-90E), the chances of further significant flares are considered increasingly slim.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	10	5	1	1
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: Cylindrical projection of the sun in 195 Angstroms, showing a relatively benign 90-120E.



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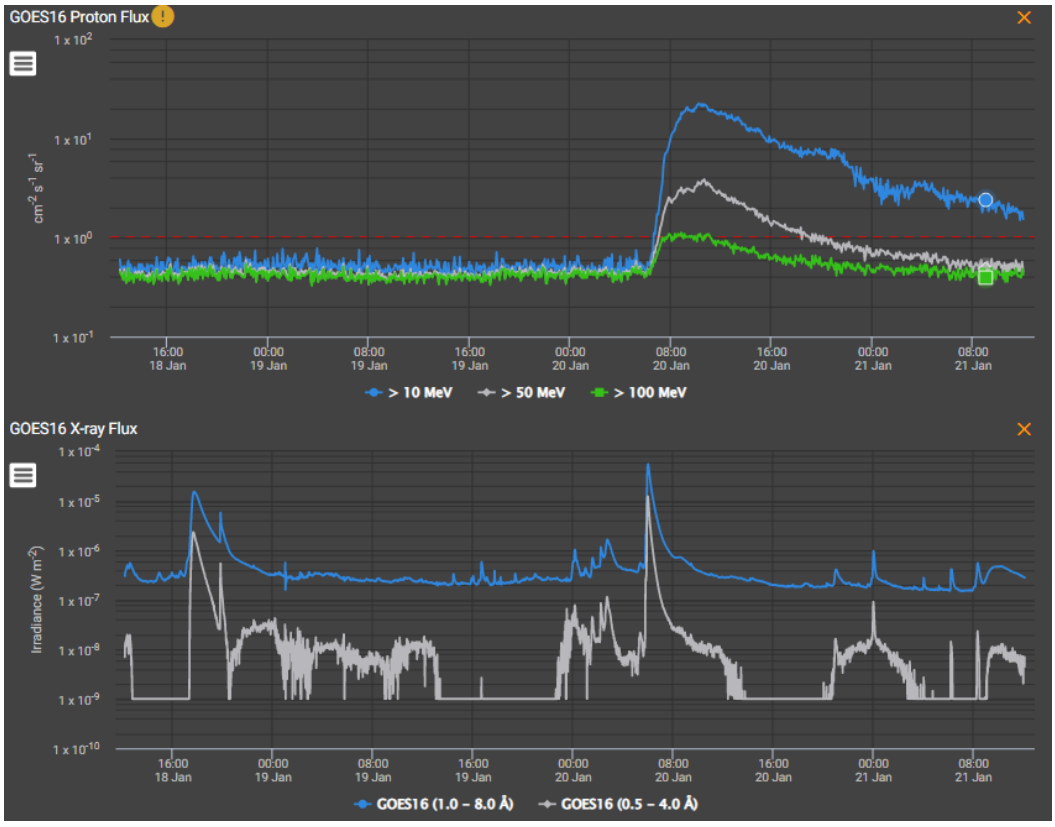
Solar Radiation Storms - (High Energy Protons):

The assumed continued presence of Ex-2929 over the western limb is maintaining the risk of further S1-level enhancements at first in the forecast period, however this risk should decline with continued far-side progression of this group in particular.

With Ex-2929 gone, the remaining cohort of sunspot groups are unlikely to sustain such risk levels, with a decay to background level of risk most likely by the end of the UTC weekend.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	10	5	2	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Past three days in: (top) GOES 16 high energy protons; (and bottom) GOES 16 X-ray flux showing the S1 solar radiation storm as well as the 100MeV response to 1pfu at peak. The observed proton flux from the M5 flare continues to decay.



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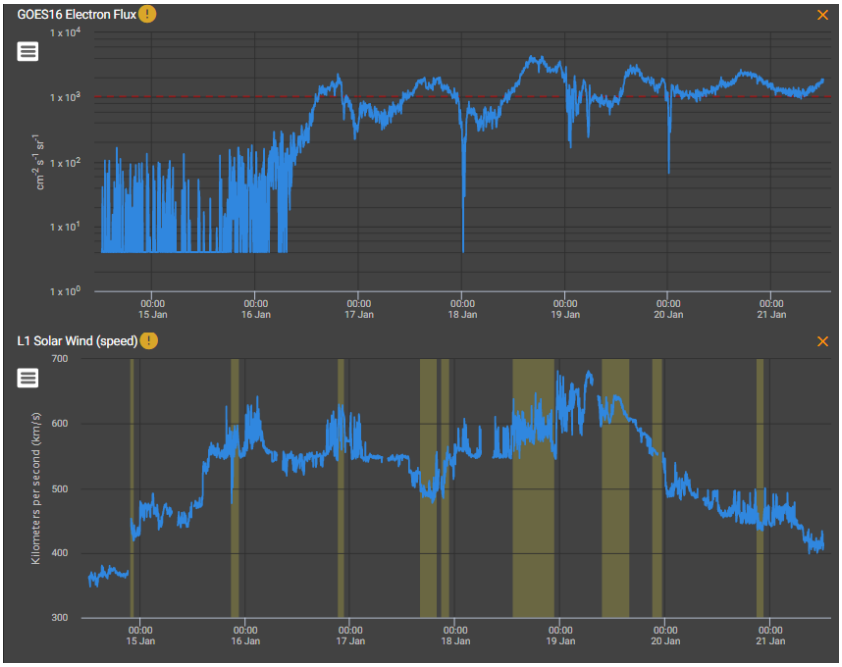
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as measured by GOES-16 at GEO, is currently High after recent fast wind and CME enhancements. The current level is likely to represent the peak of attainment in the period, with detail very low confidence for reliance on the incidence and phasing of so many transients. Of greater confidence is the resetting potential of the coronal hole high speed streams that should round out the forecast, meaning that initial Expected Active fluence should give way to a Chance from later in the UTC weekend, probably not re-establishing at current levels into the next working week.

Again because of the heavily transient-influenced forecast (or otherwise), overreliance on REFM's signal is advised against, however the advertised general downward trend is accepted.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	80	40	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Past week in high energy electrons (top) and solar wind speed at L1 (bottom). Note that the unexpected late resurgence in the high speed stream from CH44 sent the flux into a higher diurnal oscialltion than expected. With this high speed stream now declining, any geomagnetic activity arriving in the coming four-day period is most likely to establish an eventual lower diurnal oscialltion. This becomes more assured with the onset of the coronal holes rather than following any uncertain CME influence. Yellow shading represents periods of ACE data at L1 (rather than DSCOVR).



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